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Middle Ordovician Trenton Group of New York, USA

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A QUARRY FOR COLLECTING TRILOBITES AND ECHINODERMS

Classic outcrops of the Middle Ordovician Trenton Beds are exposed along the Trenton Gorge of West Canada Creek and in Mill, Cincinnati, and other creeks tributary to the Mohawk River at the town of Trenton, Madison County, New York, north of the Mohawk River valley (Fig. 71). A small hand-operated quarry on the property of W. Rust, about 1 km east of Trenton Falls, was opened by the Rust family and Charles Walcott for the purpose of collecting spectacular trilobite and echinoderm fossils from the upper beds of the Trenton Group.

Limestones of the Trenton Group are of late Middle Ordovician age (Trentonian or Caradocian Series, Mohawkian Stage), about 460 million years before present. The productive strata for crinoids occur in the Rust Member of the Denley Formation (Figs. 72, 73).

SHALLOW PLATFORM, RAMP AND BASIN

The Trenton Group comprises some 100–130 m of highly fossiliferous, thin-bedded, grey limestones with thin interbeds of dark grey calcareous shale. Limestones include a variety of lithologies, such as pelmatozoan-rich skeletal and rubbly nodular limestones with remains of bryozoans and pelmatozoans and tabular, graded micritic limestone. The latter have sharp bases, internal planar to cross-lamination and, in some instances, perfectly preserved fossils, including crinoids.

The coarser skeletal limestone facies are considered to have been deposited in shallow shelf settings. These beds show various amounts of winnowing by storm-generated waves and currents. Nodular calcarenites have undergone thorough bioturbation and, in some cases, early diagenetic cementation. The fine-grained lime mudstone beds reflect rapid deposition from low-density turbidity or gradient currents.

The Trenton carbonates accumulated on a shallow, subtropical platform and east-dipping ramp that bordered a deeper-water peripheral foreland basin to the east (Fig. 72). The latter basin was created by overthrusting of an accretionary prism (Taconic allochthon) onto the eastern (then southeastern) margin of Laurentia (ancestral North America). The basin was the site of relatively deep dysaerobic to anoxic water where a thick succession of black shales accumulated during the late Middle Ordovician. Progressive westward subsidence of this basin produced instability that triggered episodes of shelf collapse and synsedimentary slumping and sliding.

Some of the most famous Trenton crinoid–trilobite occurrences are in thin lime mudstones that accumulated through turbidity currents on the unstable ramp of the Trenton shelf sea bordering the black shale basin. Eventually, the Trenton carbonate shelf subsided in

Hans Hess, William I. Ausich, Carlton E. Brett, and Michael J. Simms, eds., *Fossil Crinoids*.

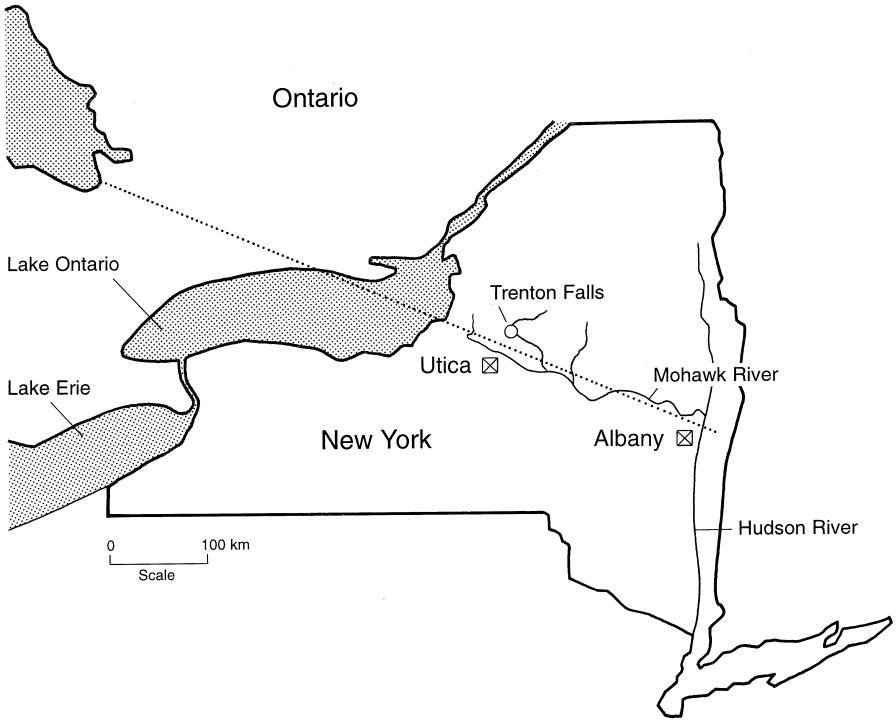

Fig. 71. Location map for Trenton Falls in the Mohawk River valley. Dotted line indicates profile of Fig. 72. (Modified from Mitchell *et al.* 1994.)

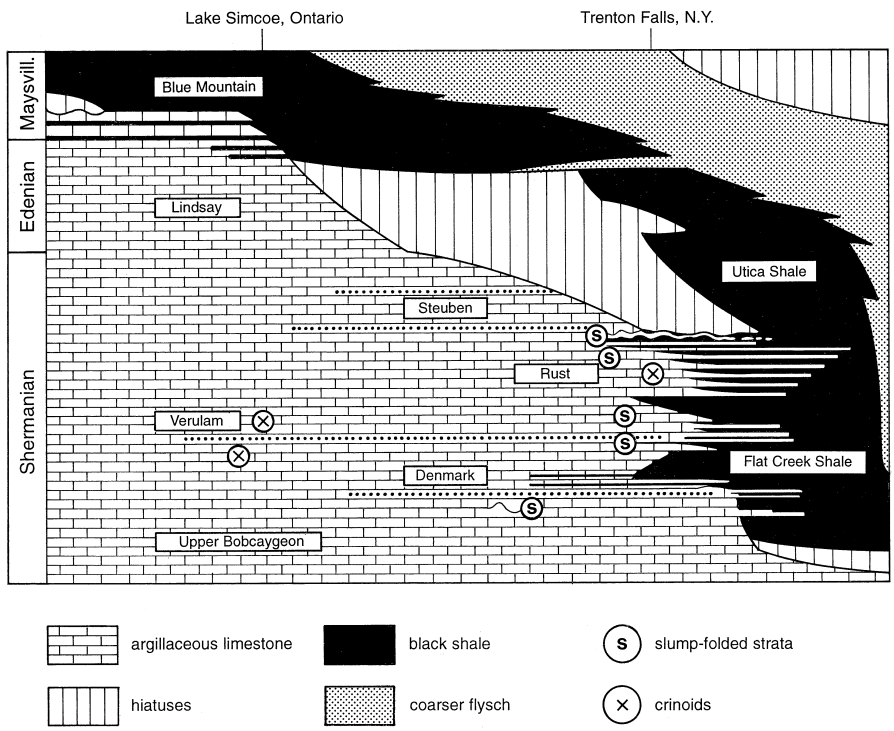

Fig. 72. Generalized stratigraphic profile for the Trenton–Simcoe Group and associated strata in Ontario and central New York State. Map in Fig. 71 shows the location of Trenton Falls. (Modified from Lehmann *et al.* 1995.)

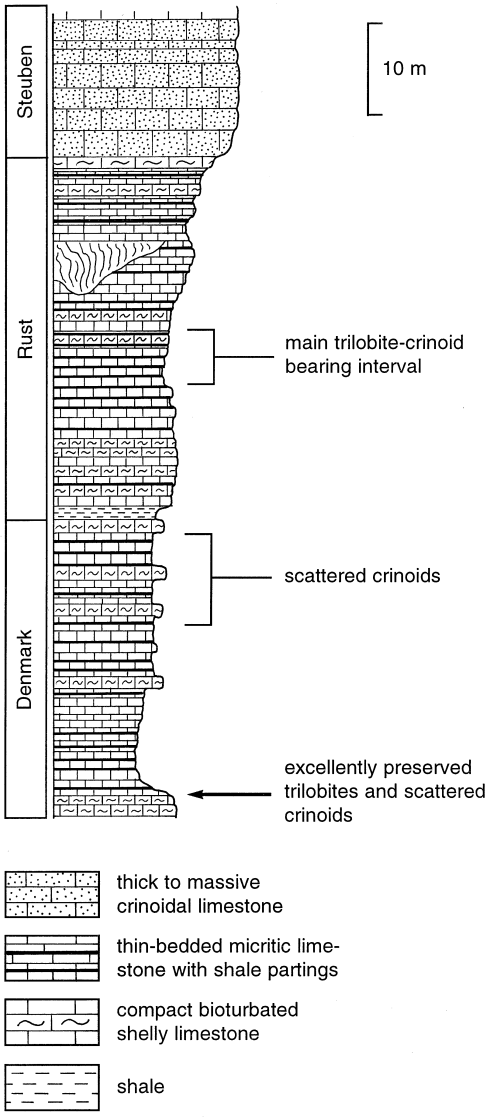

Fig. 73. Detailed stratigraphic column for Trenton Group at Trenton Falls. (Modified from Brett & Baird in press.)

central New York such that the limestones are succeeded upward by black shales and then a thick molasse sequence.

A VARIED FAUNA OF BRYOZOANS, BRACHIOPODS, TRILOBITES AND PELMATOZOANS

Approximately 75 species of fossils, including bryozoans, brachiopods, trilobites and varied echinoderms are known from the Upper Trenton Limestone in central New York. Beds rich in pelmatozoans tend to have faunas dominated by small ramose and fenestrate bryozoans and thin discoidal *Prasopora*. Brachiopods may be common and include the small strophomenids *Rafinesquina deltoidia*, *Sowerbyella* and the orthid *Paucicrura*. Abundant trilobites include exceptionally well-preserved, as well as disarticulated, material of *Isotelus*, *Flexicalymene* and, in some beds, *Ceraurus*.

Seventeen species of crinoids have been identified from the Rust Quarry beds. Crinoids are dominated by the disparids *Cincinnaticrinus* (formerly *Heterocrinus*) (Fig. 75) and *Ectenocrinus* (Fig. 76) and, rarely, the calceocrinid *Cremacrinus*. Camerates such as *Glyptocrinus* (see Fig. 53) are less abundant in most beds. One bed, consisting of a thin, turbidite-deposited lime mudstone, displays abundant, spread-out crowns of *Glyptocrinus* with the aboral side of the cup uppermost and the arms spread out with their ambulacral surfaces downward.

The pelmatozoans and trilobites of the Upper Trenton beds, specifically the Rust Quarry interval, are well articulated and composed of slightly recrystallized calcite. In the Rust Quarry beds, the disparids *Iocrinus* (Fig. 74) and *Ectenocrinus* may occur on the undersides of micritic beds, where they were apparently covered rapidly by the carbonate mud and silt. Other long-stemmed crinoids may occur on the tops of micritic beds, and a few are found obliquely through the thickness of micrite (up to 3 cm thick). Specimens of the rhombiferan cystoid *Cheirocrinus* are found in one layer with the cups oriented upright and stems downward, where they were apparently buried alive and in life position by the carbonate sediments. In some cases, crinoids with stems and crowns still intact are on the tops of nodular skeletal limestones buried by siliciclastic muds, resulting in calcareous shales. Associated complete trilobites (*Flexicalymene*, *Isotelus*, *Ceraurus*) occur on the bases of many micritic turbidites, where they are generally inverted (dorsal shield down). Other specimens occur on limestone bed tops, again buried by mud. Extraordinary specimens of enrolled *Ceraurus* in one bed at the Rust Quarry display calcified appendages.

These observations indicate that some of the Trenton communities were buried very rapidly when organisms were still alive or shortly thereafter. Such deposits were of two types – carbonate mud flows, probably the result of storm wave winnowing of shallow shelf areas, and siliciclastic mud turbidites (possibly also tempestites) that originated in the southeastern source area. Muds were probably flocculated and were deposited as silt-sized particles at rapid rates.

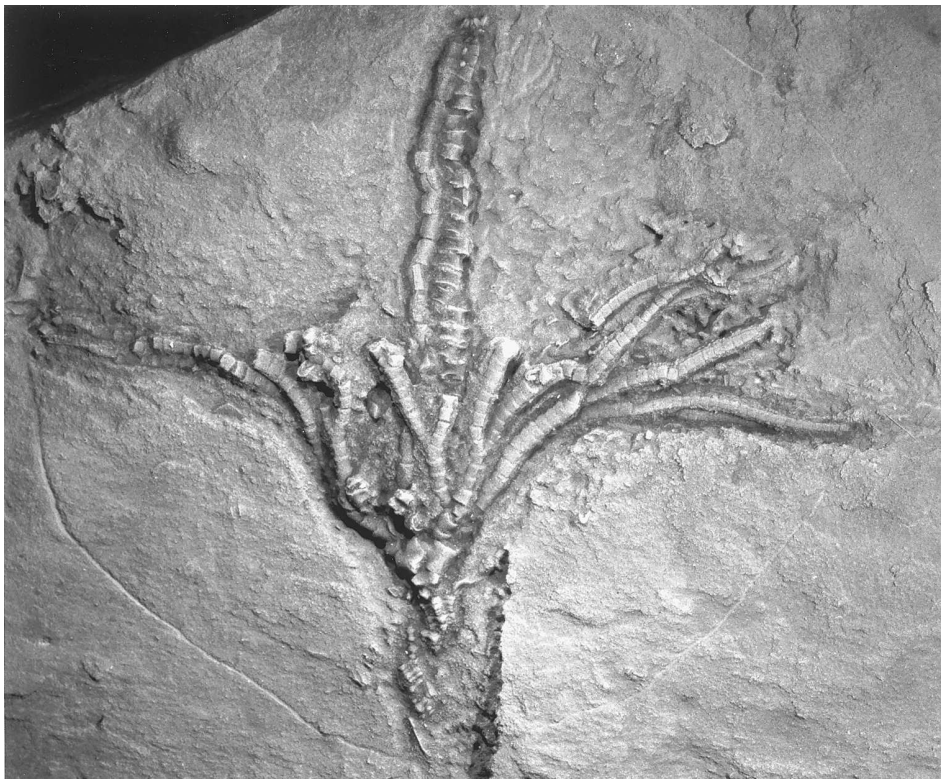

Fig. 74. *Iocrinus trentonesis* on upper surface of slab; note plicate anal sac of this cladid. Middle Ordovician Trenton Group, Rust Limestone. Rust Quarry, Trenton Falls, N.Y. (Thomas Whiteley Collection.) ×3.

AN UNSTABLE ENVIRONMENT BETWEEN SHALLOW SHELF AND DEEP BASIN

The Rust Member appears to have been deposited mostly in a middle shelf environment at water depths of a few tens of metres. The occurrence of dasycladacian algae (cyclocrinitids) in some beds suggests shallow photic zone conditions, probably less than 50 m deep (Brett *et al.* 1993). Many layers exhibit evidence of intermittent winnowing, probably by storm waves. Furthermore, the typical Rust lithology is interbedded with thicker crinoidal limestones that also pass vertically into a massive, wave-rippled skeletal limestone (Steuben Member, Fig. 73). This facies was clearly deposited in a high-energy, shallow shelf environment approaching normal wave base.

On the other hand, the best-preserved crinoids, both in the Rust and underlying Denley limestones, occur in thin intervals of calcareous shales that reflect somewhat deeper shelf conditions below normal storm wave base and affected only by the deepest storm wave base (Fig. 73). As already noted, both the calcareous shales and muds seem to reflect events of fine-grained sediment accumulation in a generally low-energy, muddy bottom environment.

These beds appear to pass, within a few kilometres basinward, into barren calcareous mud and sparsely fossiliferous dark grey shales. The former have been interpreted as carbonate turbidites; the dark shales represent siliciclastic muds that accumulated in a dysaerobic environment. Crinoids, bryozoans and most brachiopods are absent from this facies.

Thus, the best-preserved pelmatozoan assemblages occur toward the upper end of a gently sloping ramp – that is, in transitional environments between a shallow, storm-dominated shelf and a dysaerobic, deeper slope to basin. Instability within this environment is evidenced by minor slump folding and convolute bedding. This suggests that submarine seismic-induced disturbance and slumping of sediment may have been a factor in the catastrophic burial of crinoid assemblages.

IMPORTANT COLLECTION IN THE UNITED STATES

Yale Peabody Museum, New Haven, Connecticut

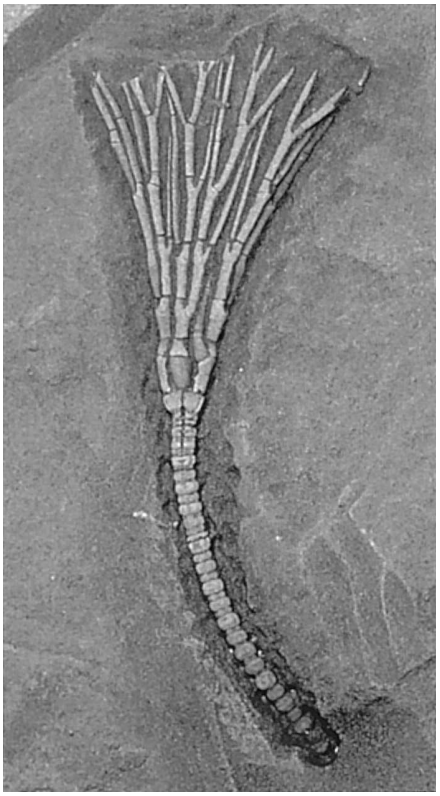

Fig. 75. *Cincinnaticrinus* (formerly *Heterocrinus) heterodactylus*. Small delicate disparid; very common on upper surfaces of limestone beds in the Rust Limestone, Trenton Group. Rust Quarry, Trenton Falls, N.Y. (Thomas Whiteley Collection.) ×2.5.

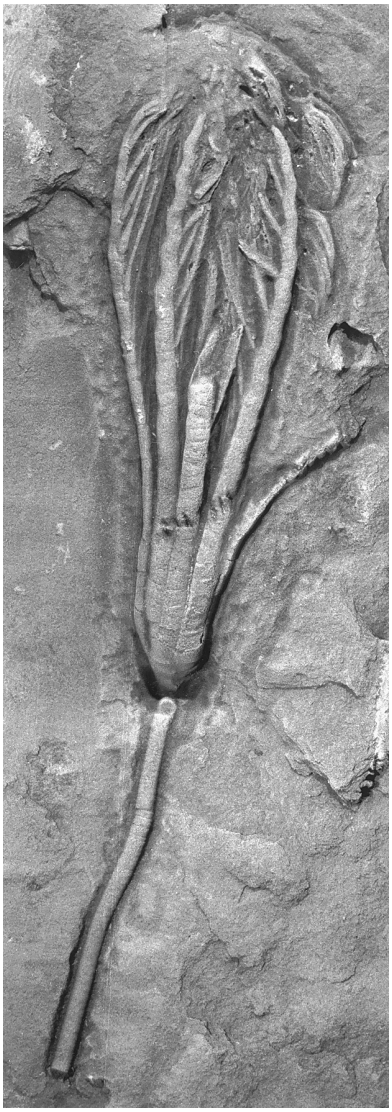

Fig. 76. *Ectenocrinus simplex*, disparid with ramulate arms. Rust Limestone, Trenton Group. Rust Quarry, Trenton Falls, N.Y. (Thomas Whiteley Collection.) ×3.